Enabling Extreme Fast Charging with Energy Storage

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Project ID: ELT237

Overview

Timeline

- Start: October 1, 2018
- End: December 31, 2021
- 15% Complete

Budget

- Total Budget: $5,831,079
- DOE Share: $2,915,377
- Contractor Share: $2,915,703
- Funding for FY 2018: $817,360

Barriers

- Power conversion – how to ensure safe, reliable operation on medium-voltage feeder?
- Battery degradation – how to ensure that high charge rates do not lead to premature wearout or catastrophic failure?
- Grid interface – how to ensure that the station does not disrupt grid operations? Can we enhance performance?

Partners

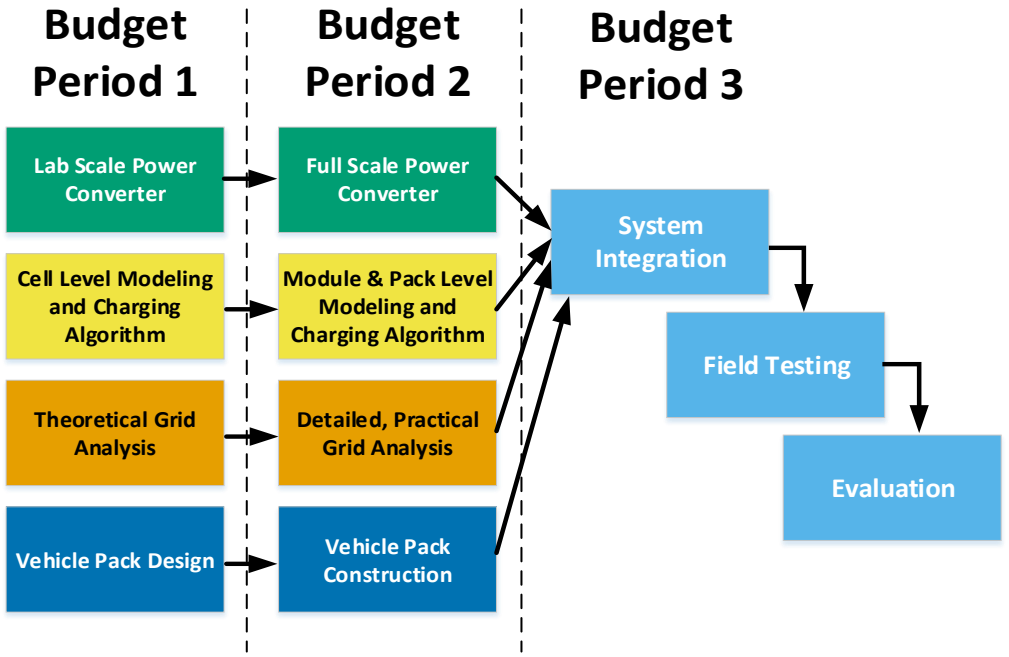
- Lead: Missouri S&T, Kimball
  - Also Bo, Ferdowsi, Landers, Park, Shamsi
- Ameren: utility
- Bitrode: equipment manufacturer
- LG Chem Michigan: battery mfg

Relevance

- Overall Objectives
  - Charging station connected to 15 kV class, 1 MW
  - Mitigate impact on battery degradation
  - Mitigate impact on the grid
- Objectives This Period
  - Define topology, gather information on grid and battery construction
- Impact
  - Accelerate adoption of electric vehicles
  - Provide economic benefit to charging station owner

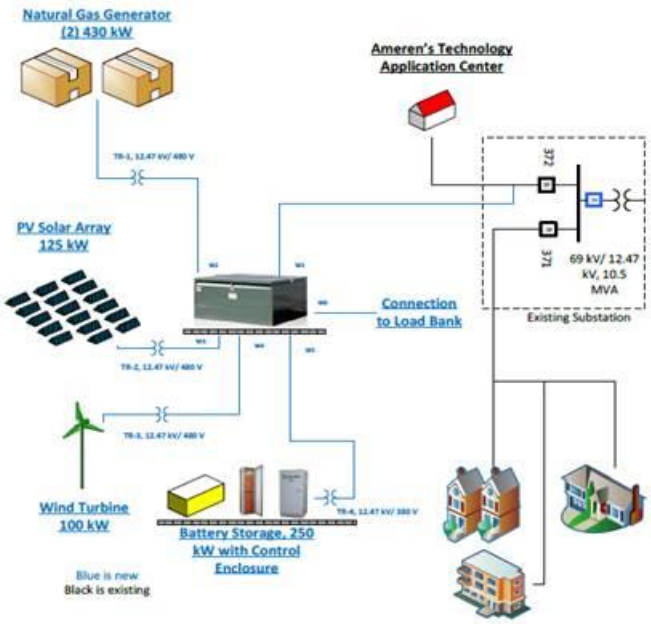
Approach

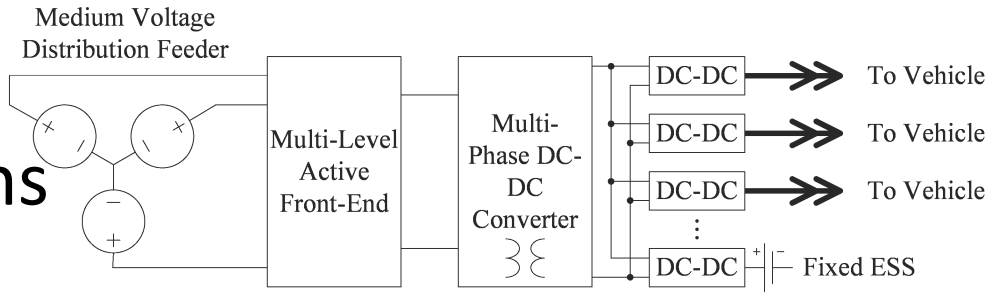
- Budget Period 1 focused on proof-of-concept, culminates in feasibility go/no-go
- BP2 will focus on reaching full scale
- BP3 includes
  - Integration
  - Field Test
  - Evaluation



Technical Accomplishments and Progress

- Subscale design: 1247 V in, 100 V out, 10 kW
- Transformer design for low coupling capacitance
- Battery degradation models being integrated with charge profile optimization
- Beginning analysis of Technology Applications Center feeder





Partners/Collaborators

- Ameren – utility in Missouri and Illinois
  - Network data; field testing at Technology Applications Center (TAC)
- Bitrode – battery equipment manufacturer based in St. Louis
  - Will build full-scale prototype
- LG Chem Michigan – battery (and pack) manufacturer
  - Battery data; vehicle pack; stationary pack (energy storage system, or ESS)

Proposed Future Research

Current

- Complete subscale development, cell-level modeling, grid initial study

Budget Period 2

- Scale power converter to 12.47 kV, 1 MW
  - Add four battery interface modules
- Develop module- and pack-level charging algorithms
- Complete detailed grid analysis and design controller that mitigates impact, provides revenue
- Vehicle battery pack design and construction

BP3

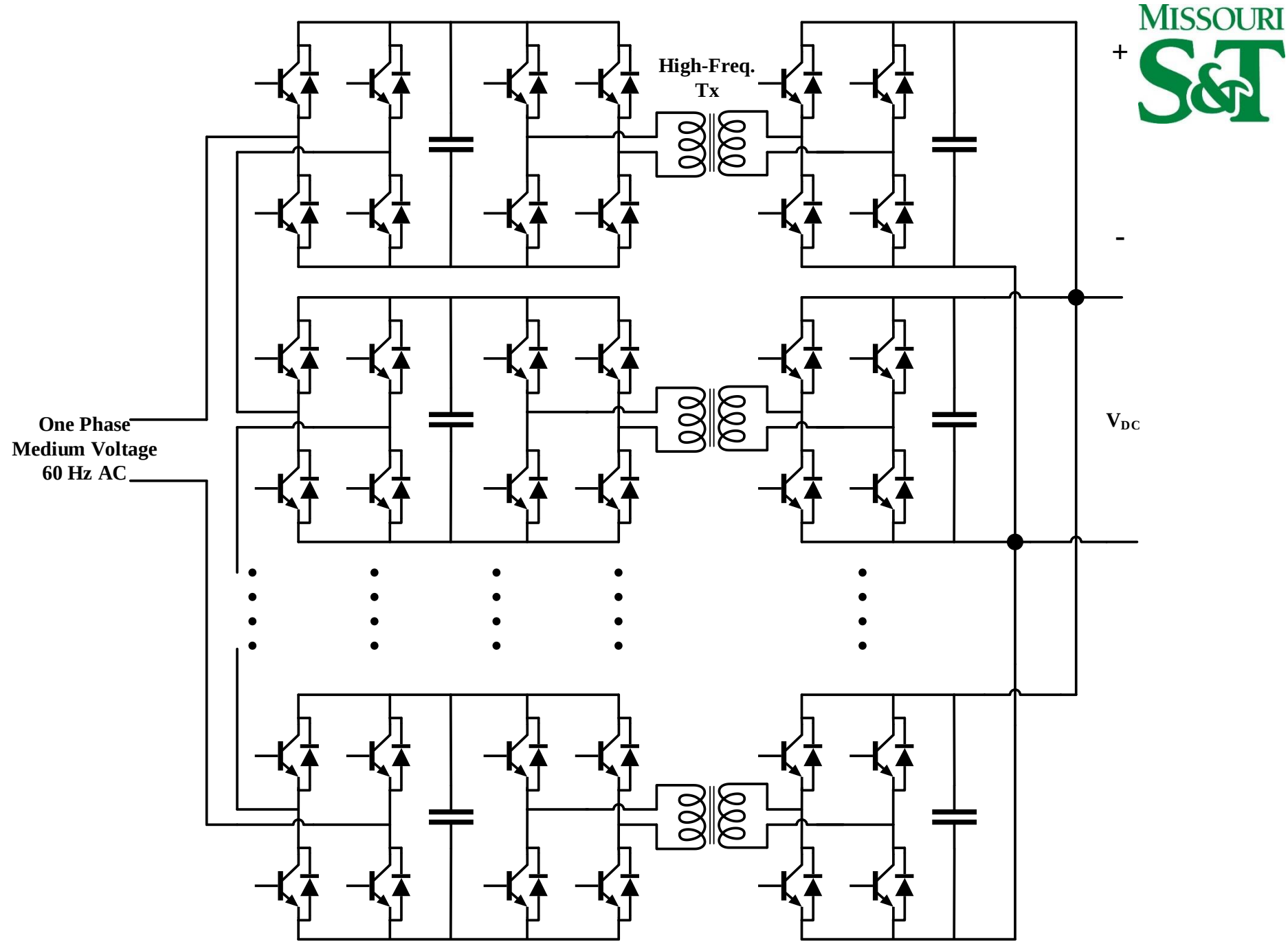
- System integration and field testing

Any proposed future work is subject to change based on funding levels.

Summary

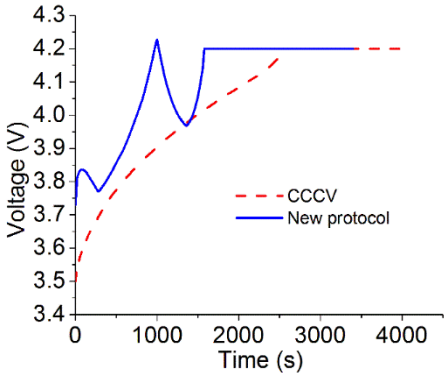
- Developing an extreme fast charging (XFC) station that connects to 12.47 kV feeder, uses advanced charging algorithms, and incorporates energy storage for grid services
- Subscale development in progress
- Then will scale up, integrate, and test to demonstrate capabilities

Technical Back-Up Slides

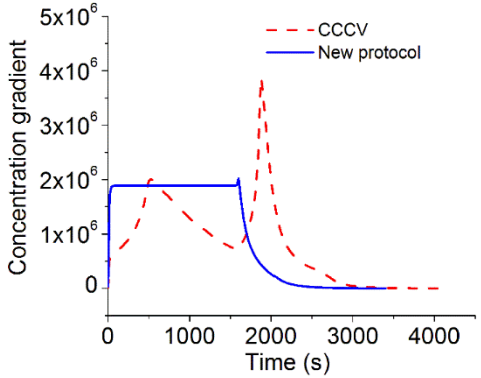

High-Freq.
Tx
+
-
V_{DC}
One Phase
Medium Voltage
60 Hz AC

Example Results of Model Predictive Control

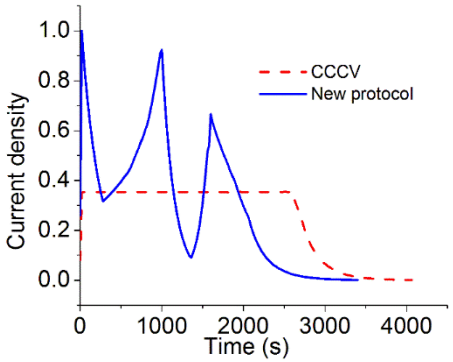
Voltage



Concentration Gradient



Current Density



$$J\left(I, SOC, SOH, T, t_f\right) = \int_{t_0}^{t_f} w dt + \left(1-w\right)\left(SOH\left(t_0\right) - SOH\left(t_f\right)\right)$$

Ameren TAC

Ameren Technology Applications Center

- **Northern Power Wind Turbine**: 100 kW @ 480 V, 160’ height
- **Yingli/ABB Solar Array**: 125 kW, 0.8 acre
- **Caterpillar Natural Gas Generators**: 2×500 kW, 625 kVA @ 480 V
- **S&C/LG Chem Battery System**: 250 kW, 500 kWh